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A new *Dichotrachelus* Stierlin from Val Grande (Piemonte, Italy) (Coleoptera, Curculionidae) with comments on biogeography and evolution of high alpine species of the genus

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Abstract

Dichotrachelus sonjae **sp. nov.** was discovered in a cold north-exposed scree slope in the Togano ridge area in Piemonte North of Val Grande. It is described and compared with the most similar species. Based on morphology and molecular data presented here, *Dichotrachelus lepontinus* Osella, 1971, distributed from Piemonte in Italy (Monte Rosa) eastwards to the Misox mountains of Switzerland, is its sister species. *Dichotrachelus meregallii* Osella, 1971 is another closely related species. Phylogeographic and biogeographical considerations on the development of that particularly lithophilous and high alpine living group of *Dichotrachelus* are presented.

Key Words

Cyclominae, new species, scree slope, biology, alpine fauna, Southern Alps

Introduction

While exploring the Alps in search for high alpine relic species, we discovered a new *Dichotrachelus* Stierlin, 1853 species in Piemonte, Italy. *Dichotrachelus* are cryotolerant weevils that can inhabit cold-humid and rocky habitats at alpine altitudes, where they develop and feed on mosses (Meregalli 1980) and *Saxifraga* spp. (Meregalli et al. 2013). The genus is distributed with 60 species in Europe and Northern Africa and all species are wingless and thus not very mobile, often restricted to small distribution areas and thus endemic (Meregalli et al. 2018). Osella (1971) provided a revision of the genus. With the addition of the new species here, 34 different taxa are now recorded from Italy (Alonso-Zarazaga et al. 2023).

We have collected *Dichotrachelus* all over Switzerland and adjacent regions of the Alps within the last 20 years, and together with data from colleagues we can give exhaustive information on the distribution of the closest species of our new one, specifically regarding *D. lepontinus* Osella, 1971 and *D. meregallii* Osella, 1971. We also use mitochondrial sequence information to compare the new species with the closest ones.

High alpine species of *Dichotrachelus* are of general significance because they provide an outstanding view into biogeography and evolution of insects driven by the fluctuations of the glacial periods, an endeavor earnestly put forth by Holdhaus (1954).

Material and methods

Repositories of examined material: NMB – Naturhistorisches Museum Basel; NMBE – Naturhistorisches Museum Bern; cAS- collection Alexander Szallies (Reutlingen); cCG – collection Christoph Germann (Rubigen);

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cMM – collection Massimo Meregalli (Torino); cRM – collection Riccardo Monguzzi (Milano); cVR – ex collection Vittorio Rosa (Museum für Naturkunde Stuttgart). Abbreviations used: L/B: Length versus breadth; n. c.: not counted.

All specimens studied for comparison are listed in the Suppl. material 1: table S1.

The Cox1 sequence data provided here (Suppl. material 1: table S3) consist of 658 nucleotides (corresponding to the full-length of the so-called barcode). The laboratory protocol used followed the one given in Germann et al. (2022). From the nucleotide alignment, a Jukes-Cantor (Jukes and Cantor 1969) corrected Neighbor-Joining (NJ) tree was built using MEGA software (Kumar et al. 2004). Apart from own unpublished data, we used two reliable sequences from Genbank (MW649095.1 and MW649092.1) published by Meregalli et al. (2021). The p-values matrix is given in the Suppl. material 1: table S2. Images were taken by C.G. with the VHX-7000 photosystem by Keyence at the NMB. Label data is given verbatim within quotation marks.

Results

Dichotrachelus sonjae sp. nov.

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Holotype. Male "440_24.3 ITALIA, Piemonte, Valle Vigezzo, Druogno, unterh. Pizzo Nona, 46.09943, 8.41411, 1950 m, GS Moos Blockhalde, 31.10.2024, leg. C. Germann" (NMB).

Paratypes. 50 ex. "440_24.3 ITALIA, Piemonte, Valle Vigezzo, Druogno, unterh. Pizzo Nona, 46.09943, 8.41411, 1950 m, GS Moos Blockhalde, 31.10.2024, leg. C. Germann". – 22 ex. "440_24.4 ITALIA, Piemonte, Valle Vigezzo, Druogno, unterh. Pizzo Nona, 46.09942, 8.41492, 1910 m, GS Moos Blockhalde, 31.10.2024, leg. C. Germann". – 4 ♂, 2 ♀ "Druogno, Pizzo Nona Nordseite 2000 m, 9.8.2024, leg. Szallies". – 15 ♂, 38 ♀ "Druogno, Pizzo Nona Nordseite 2000 m, 31.10.2024, leg. Szallies". (cCG, cAS, cMM, cRM, NMB, NMBE).

Description. Size: 3.3–4.2 mm (♂ 3.3–4.0 mm, ♀ 4.0–4.2 mm), Figs 1–4, 9, 11–15.

Body colour: Black to dark brown, antennae and legs reddish brown. Head, rostrum and antennae: Head globose, irregularly punctate, raised broad dark brown scales on frons. Thinner, clubbed scales on epifrons up to antennal scrobes. Eyes weakly protruding, oval.

Rostrum about twice as long as wide (L/B): 1.9–2.0; epifrons of rostrum shiny and irregularly striated-punctuated; rostral apex glossy and shiny, irregularly punctuated and with erect bowed setae; antennal scrobes visible from above, diverging towards eyes, in lateral view bowed downwards, limited by a horizontal ridge extending from lower end of eyes to lower limit of scrobes.

Antennae strong, inserted on last third of rostrum; antennal scapes (L/B: 6.5) slender in its first third, then continuously broadened to three times as wide as width at base; dark brown, with clubbed scales from broad half of antennal scape; first segment of antennal funicles more than twice as long as wide, following segments as follows (L/B): 2nd: 1.6, 3rd to 7th: 1.0; antennal clubs (L/B: 2.1) twice as wide as last antennal segment, consisting of three visible segments.

Pronotum: Index (L/B): 1.12–1.14. Longer than wide, laterally weakly rounded, widest at middle, at fore and hind margins only weakly constricted; vestiture consisting of adherent and raised strong, clubbed mainly dark brown scales with several light brown scales intermixed, especially along middle.

Elytra: Index (L/B): 1.53–1.71. Base slightly broader than prothorax, subelliptical, without humeral calli, oval, widest along middle; uneven intervals including suture weakly elevated, wider than deeply punctuated striae; elytral disc slightly flattened (lateral view); integument covered with two types of scales: semi-raised, short and rounded or oval scales, and raised clubbed scales, up to twice as long as wide. Scales mostly dark brown; several patchily arranged light brown scales intermixed.

Legs: Strong and slender, with elongate, bowed, dark brown scales and thinner light brown scales; apex of tibiae with a pair of lobal formed spines, reminding of spurs, with their tips subparallel projecting ventrally (Figs 14, 15). Three visible tarsal segments, first and second of same length, third 1.5× as long as wide and distally bilobed, fourth tiny, hardly visible, claw segment twice as long as third one, claws simple.

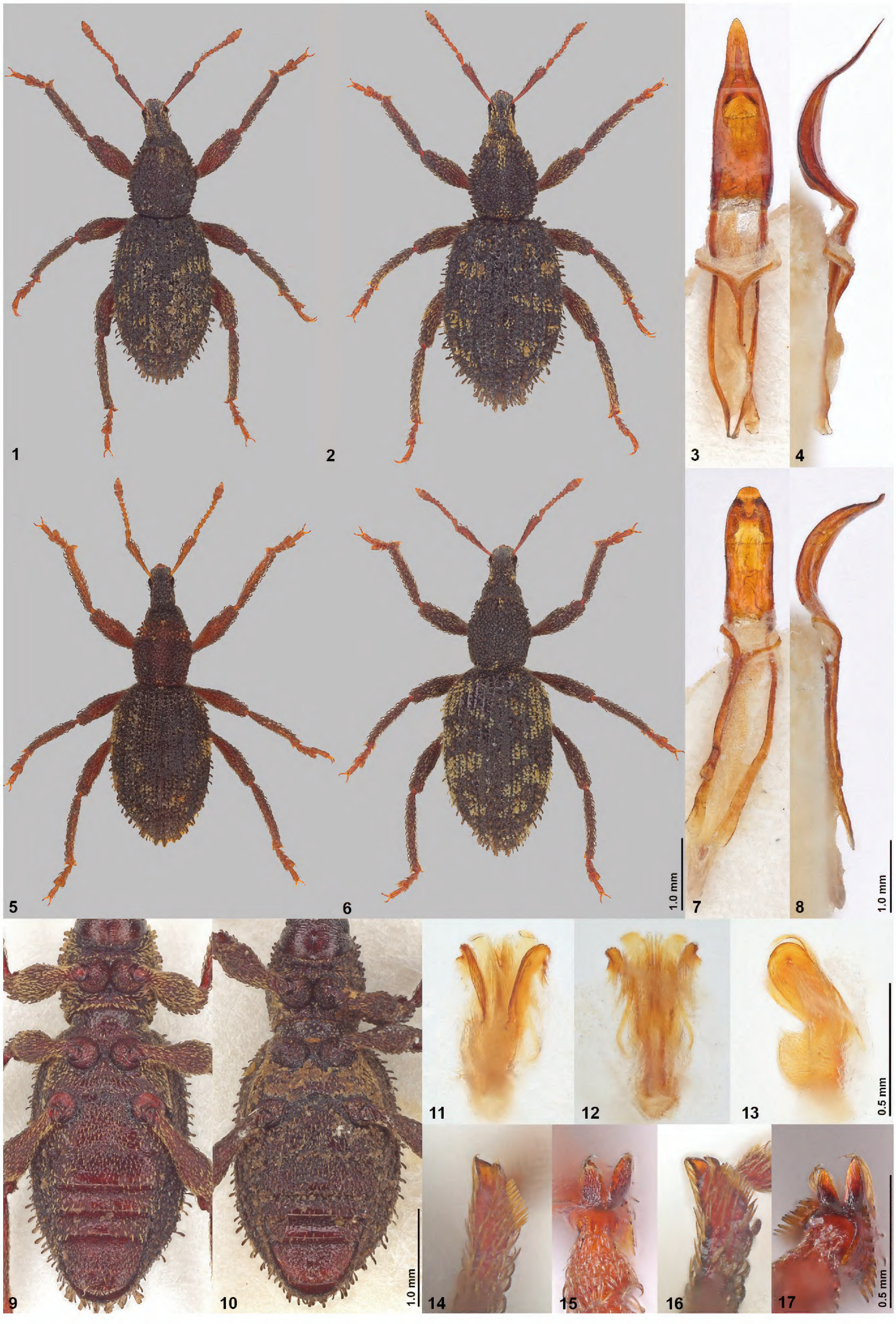
Aedeagus: Base of penis evenly sclerotized; ostium of penis oval and discreet, twice as long as broad. Penis, towards distal tip, with basal half covered by a thin translucent sclerotized sheath; at anterior end of ostium, penis with long dagger-like apex (Figs 3, 4); internal sclerite with small central doublet and split inner arms with thick and bowed anterior arms surrounding central part. Encompassing sheath, valves forming a double lobed structure reminding of butterfly wings, as best seen in lateral view of single "valve"; sheath of internal sclerite evenly rounded, carrying lateral sclerites at middle of each of valves (Figs 11–13).

Female genitalia: Sternite VIII (Fig. 18), spermatheca (Fig. 20) and gonocoxites (Fig. 22).

Sexual dimorphism: Elytral shape of male laterally parallel (in females slightly convex), spurs of tibiae in males more pronounced than in females. Fifth sternite of males more broadly rounded apicad than in females, with a more pointed arch-like apical margin (Fig. 9).

Derivation of the name: In deep gratitude and love the name of the new species was given by the first author to honor his wife Sonja, in compliance with provisions outlined by Lohse (1964).

Biology. While collecting the adults of *D. sonjae*, we encountered several larvae hidden in the dense moss cushions in the scree slope in late autumn (Figs 24, 25). We were surprised to find not only large larvae in the last larval stage (Fig. 26) but also tiny larvae in the first larval stage, hardly one millimeter in length (Fig. 27).



Figures 1–17. *Dichotrachelus sonjae* and *D. lepontinus*. **1**, **2.** Male and female of *D. sonjae*; **3**, **4.** Male of *D. sonjae* aedeagus ventral and lateral view; **5**, **6.** Male and female of *D. lepontinus*; **7**, **8.** Ditto, aedeagus ventral and lateral view; **9.** Ventral view of *D. sonjae*; **10.** Ditto, *D. lepontinus*; **11–13.** Internal sclerite of aedeagal sac of *D. sonjae*, dorsal, ventral and lateral view; **14**, **15.** A pair of spinal projections on the ventral base of left protibia, the duplex lobal spurs, dorsal and lateral view of *D. sonjae*; **16**, **17**. Ditto, *D. lepontinus* (Photos: C. Germann).

Figures 18–23. Female genital organs of *D. sonjae*. and *D. lepontinus*. **18, 20, 22** Female genitalia of *Dichotrachelus sonjae*. **18.** Sternite VIII; **20.** Spermatheca; **22.** Gonocoxites. **19, 21, 23** Ditto of *D. lepontinus* (Photos: C. Germann).

Differential diagnosis. *D. sonjae* is morphologically most similar to *D. lepontinus*, described from Cimalmotto (Ticino, Switzerland) and differs mainly in the unique dagger-like tip of its penis (Figs 3, 4 compared to 7, 8). Females may be separated by their spermathecae and sternites VIII. The edged projection at the base of the spermatheca of *D. lepontinus* (Fig. 21) is totally absent in *D. sonjae* (Fig. 20).

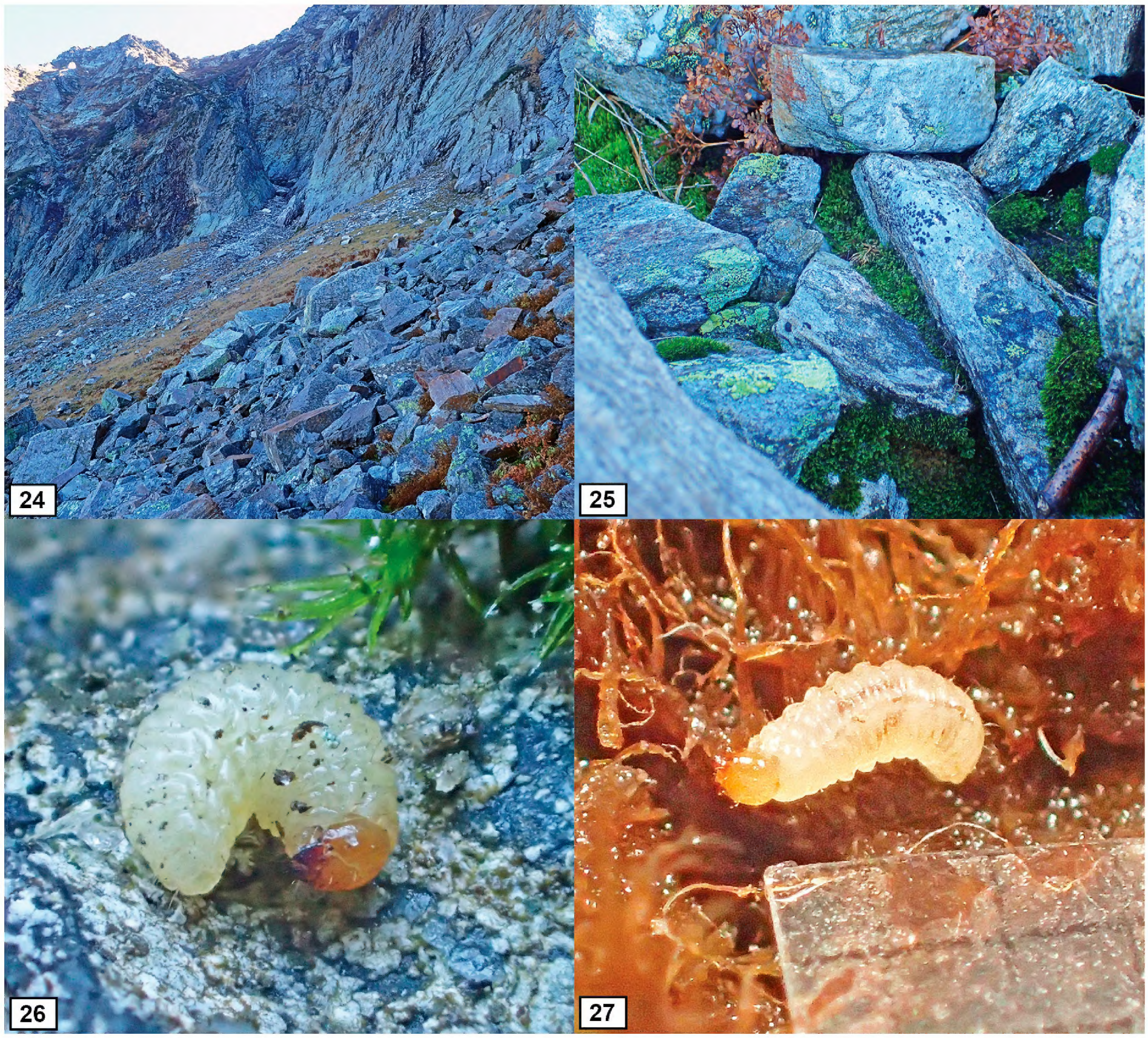
The morphological differences between *D. sonjae* and *D. lepontinus* are as follows: Shape of elytra in males more elongate oval, shoulders more reduced, more slender in *D. sonjae* (Figs 1, 2), elytra wider oval and wider at shoulders in *D. lepontinus* (Figs 3, 4), pronotum in both sexes little more rounded laterally in *D. sonjae* (Figs 3, 4). Legs, femora stronger and thicker in *D. sonjae*. Erect scales on elytra and pronotum are a little thicker and stronger in *D. sonjae* than in *D. lepontinus*. In females, both species have a very narrow sternite VIII, in *D. sonjae* the plate is wider (Figs 18, 19).

Remarkably, both species share a heavy sclerotization of the aedeagal tubular base, with a distinct delineation marked by the ostium, occurring amongst *Dichotrachelus* of the Alps only also in *D. rudeni* Stierlin, 1853 and *D. imhoffi* Stierlin, 1857. The ostium of the penis in *D. sonjae* is much more reduced in length than in *D. lepontinus*, to an oval orifice nearly twice as long as wide, while in *D. lepontinus* the ostium is much longer with clearly weaker sclerotization of the aedeagal base.

Another species similar to *D. sonjae* is *D. meregallii*, which appears to be the only other *Dichotrachelus* species sharing the double (duplex) lobal spurs with *D. sonjae* and *D. lepontinus*. In *D. meregallii* the posterior tibiae possess only one apparent single spur that is markedly larger and longer than any of the duplex spurs of the other tibiae of *D. lepontinus* and *D. sonjae*, respectively. This seemingly single spur is in fact consisting of two separate ones (magnification 100×). Notably, one specimen of *D. meregallii* from a population at unusually low altitude (Valle di Lanzo, Ceres), exhibits intermediate states of spur fusion on the meso- and faintly on the protibiae.

Another species preferring rocky habitats in a high alpine environment is *Dichotrachelus augusti* Solari, 1946, which shares the slender and long tibiae with *D. sonjae*. It also has spurs on its tibiae, but these are singular, fine, short, and pointed. The basal part of its aedeagus is weakly sclerotized, but more so than in *D. meregallii*.

Molecular data. Mitochondrial genetic data confirmed the putative close association between *D. sonjae* and *D. lepontinus*, the pairwise sequence distance of which exhibited 5.9–6.5% difference in mitochondrial Cox1 (p-distance; Suppl. material 1: table S2), whilst all other species examined exhibited at least 11% and more. Intraspecific variation was found to be up to 0.61%.



Figures 24–27. 24, 25. Habitat of *D. sonjae* in the scree slope north of Pizzo Nona at nearly 2000 m a.s.l. (corresponds to the line ending with the rock face above). The extraordinary coldness of this place is due to the extra cavity carved into the north face of Pizzo Nona, that can be seen in Fig. 24 above the middle in the picture, thus the habitat is deprived from direct sunlight most of the year; **26**, **27.** Last and first larval stages of *D. sonjae* collected in moss cushions growing on granite stones in the scree slope (Photos: C. Germann).

Discussion

Biogeographical assessment and alpine fauna of the type locality of *D. sonjae* sp. nov.

Two days of collecting (9th August and 31st October 2024) revealed a remarkably large population of the alpine carabid species *Nebria casalei* Giachino, 2013 (in our opinion belonging to *Nebria cordicollis* sstr.) in the exceptionally cool talus above the open blockfield area where *D. sonjae* sp. nov. is most common (Fig. 24). At the north face's rocky edge the common *Dichotrachelus rudeni* Stierlin, 1853 was sifted from mosses. *Trechus ceresai* Binaghi, 1938 was rare in this environment, which consists of interspersed instable granite and is therefore not accommodative to cavity dwellers as this *Trechus* endemic to the northern ridge of Valle Grande eastwards to Monte Zeda (leg. Szallies). Notably, no Staphylinids were found and thus most strikingly not a single *Leptusa* specimen could be collected. In the vicinity between Toce and Lago Maggiore. *Leptusa* species seem to occur only on Monte Gridone in Switzerland, where *Leptusa monacha* (Fauvel, 1898), *Leptusa monguzzii* Pace, 1989 and *Leptusa pilatensis* Scheerpeltz, 1972 (nominate form from CH) could be collected (leg. Szallies), and the first two species were also recorded from Cima Laurasca (leg. Monguzzi, i.l.). Monte Gridone, on the other side, harbors *Trechus piazzolii* Focarile, 1950, the vicariant of *T. ceresai*, suggesting a different origin of the fauna of the Eastern Gridone aerea than that of the Western Toce region.

As the widespread *D. rudeni*, *D. lepontinus* also occurs on Monte Gridone, westwards to Cima Laurasca. Apparently, no *D. lepontinus* was ever recorded from Valle Grande's Togano ridge area (not mentioned by Giachino 2013), where *D. sonjae* sp. nov. was discovered.

The distribution of the high alpine species *Nebria cordicollis* in the mountains of Val Grande may also be explained by its colonialization from the Gridone area. There it occurs in the talus of scree slopes below 2000 m a.s.l. as well as in the near-by mountain range to the north between rivers Toce and Maggia, where *N. cordicollis* ominously is rare, difficult to collect and thus neglected. Adults of *N. cordicollis* of Val Grande can be found in the watersprings from underground talus scree bodies and therefore they were assumed to belong to some cold stenothermous species of running water (Giachino 2013). Certainly, the occurrence of *N. cordicollis* in the Val Grande ridge is a glacial relic phenomenon as with the closely related *Nebria heeri* Daniel, 1909, which lives as glacial relic species in the Black Forest scree slopes even below 1000 m a.s.l. (Huber and Molenda 2004; Szallies and Huber 2013). In this environment the hygrophilous adults are totally absent at the surface in the night, when they are active. Similar seems to be the situation with *N. cordicollis* in suboptimal habitats on Cima Laurasca or Monte Zeda.

Phylogenetic and biogeographic interpretation of *D. sonjae* sp. nov.

Our results suggest *D. sonjae* sp. nov. to be the sister taxon of *D. lepontinus*. Both share, quite unique among *Dichotrachelus*, the duplex lobal spurs on all their tibiae as well as a heavily sclerotized basal part of the penis with an adjacent distinct ostium with delineated basal borders. The similar *D. meregallii*, which shares the trait of duplex spurs of tibiae, shows an unsclerotized dorsal surface of the basal region of the aedeagus, hollow inside and thus lacks a true ostium, similar to most *Dichotrachelus* species of the Alps. Instead, these species possess a faintly sclerotized sheath covering the cavity of the dorsal surface of the aedeagus that is truncated to form a blunt ended orifice.

The duplex spurs at the base of tibiae (as well as the extra large single spur on the metatibiae of *D. meregallii*) might endow its carriers with an extra advantage to move and live in pure rocky habitats such as scree slopes and steep cliffs, while the common and more widespread species with small spurs regularly occur in less rocky habitats. There seems also some sexual selection involved, for the males having a bit more prominent spurs in all three species considered. Accordingly, tibiae of these three species with clear preference of extremely rocky habitats are longer than in the common ubiquitous species substituting them in less rocky habitats, as *D. rudeni* or *D. stierlini*. Most likely it is the humid microclimate in scree slopes that renders these extremely stony habitats particularly good habitats for *Dichotrachelus* species because their feeding plants, mosses, proliferate very well there.

Another species preferring rocky habitats in a high alpine environment is the already mentioned *D. augusti* sharing the slender and long tibiae, with short, singular, but very pointed spurs on its tibiae. Different populations of *D. augusti* and *D. meregallii* occur besides each other scattered in the wider Grand St. Bernard area north of Aosta (Germann 2011), while in the core Monte Rosa area (I and CH) only *D. augusti* was found and *D. lepontinus* solely in the lower regions towards the Toce valley. The population of *D. sonjae* sp. nov. in the exceptionally cold scree slope of the north face of Pizzo Nona of Valle Grande might be a singular relict one. It is not unlikely, however, that further populations exist in the core Monte Rosa area or in more distant places as the isolated population of *D. meregallii* in the Ortles region might imply.

Genetic data confirm the close relationship of *D. sonjae* sp. nov. and *D. lepontinus*, with only 6% divergence between them, whilst all the other *Dichotrachelus*, including *D. meregallii* exhibit up to 20% difference towards each other, leaving little space for further chance to accumulate and thus maybe obscuring the discernment of actual phylogenetic lineages. Remarkably, only *D. rudeni* and *D. imhoffi* exhibit a similar close relationship, with only 5% sequence divergence (Meregalli et al. 2018).

It is puzzling to state that the separation of two disjunct populations of *D. meregallii* (Fig. 28) must be considered a most recent event (about 2.5% divergence according to Meregalli et al. 2021), whilst the separation of *D. lepontinus* and *D. sonjae* sp. nov. must have happened considerably before. The huge spatial distributional gap between populations of *D. meregallii* may be due (at least in part) to the competition of *D. lepontinus* and *D. sonjae* sp. nov. in between, as well as of *D. augusti*, an additional species capable to compete with the other three species (personal observations). In its eastern distribution area, *D. meregallii* predominantly lives in the high alpine moraine block fields of the large glaciers of the Ortler system, but is also present on high altitude ridges and cliffs, above 3000 m a.s.l. In blockfields around 2500 m a.s.l. and on more grassy terrain, *D. stierlini* dominates everywhere and Holdhaus (1954) outlined that he had found the species in large numbers in Martelltal even above 3000 m a.s.l. It is noteworthy then, that the fortunate absence of *D. stierlini* from the Sulden Valley allowed for the discovery of *D. meregallii* by Gert Müller in the shallow debris fields there, an otherwise precluded biotope dominated by *D. stierlini*. If there is any species that might be eligible for a nunatak survivor species, *D. meregallii* should be considered prime candidate, since the Ortler region must be considered one of the most devastated and most poorly recolonized of the Alps with no native fauna (Holdhaus 1954). Closer investigation of the Ortler system, however, has revealed a more nuanced picture, with a record of *Trechus tristiculus* Daniel, 1898 in the Serottini range and the

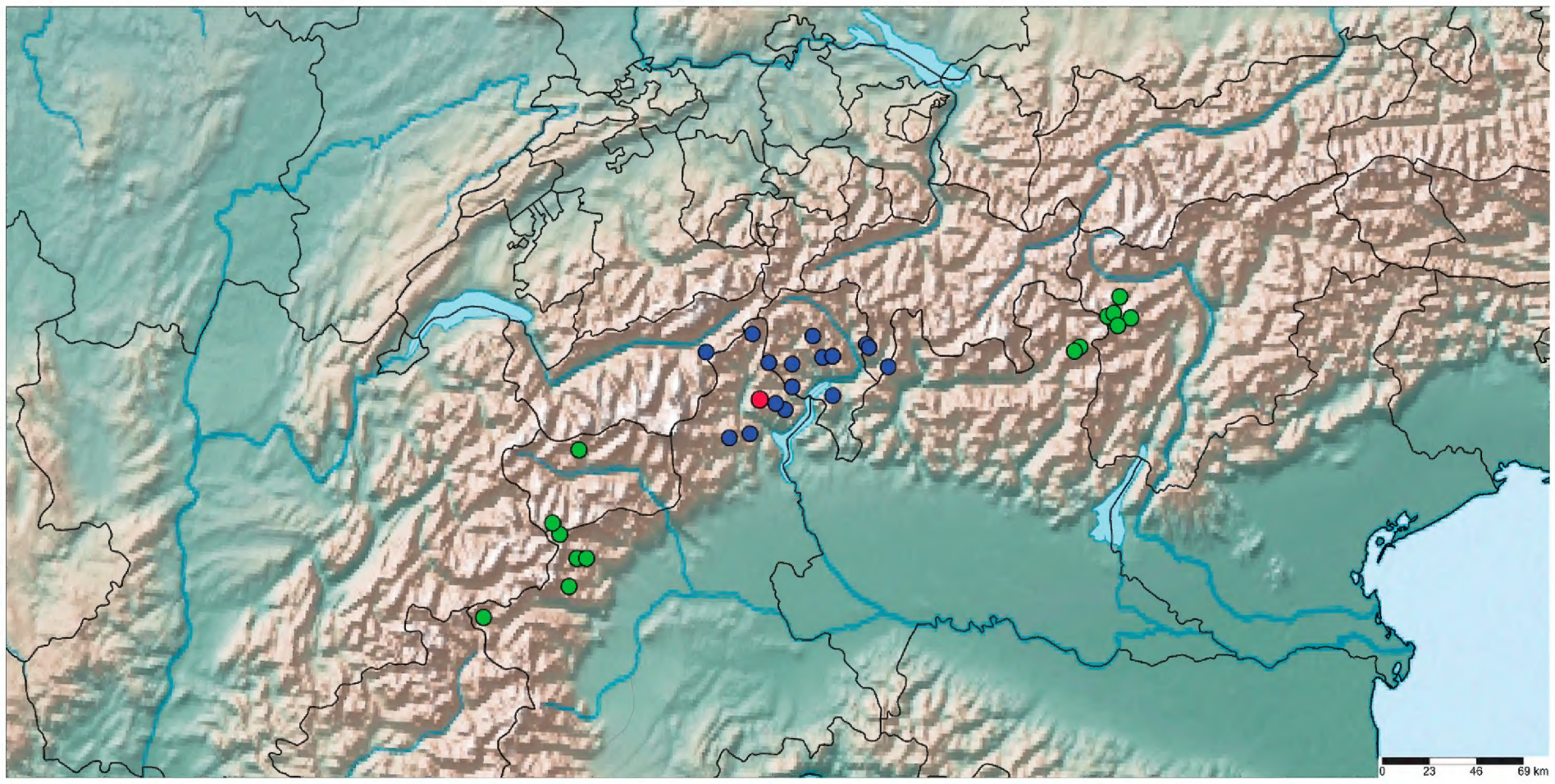


Figure 28. Distribution of *D. lepontinus* (blue dots), *D. meregallii* (green dots) – note the strong disjunction of populations – and the single locality of *D. sonjae* (red dot) based on our studied specimens (Suppl. material 1; map simplemapper).

nearby Val Carrè. It appears likely, that the Ortler system did in fact harbor a low altitudinal zone of general survival, a *massif de refuge*, most likely north of Edolo, where *D. meregallii* could as well have persisted the last glacial maximum alongside this *Trechus*, that has its next populations south of the Adamello group and in the Brenta. The population of *D. meregallii* in the West (Fig. 28) might have persisted the glaciation in the region of the lower river La Iserè, from which it might have reached all present localities within the same time, in particular the locality near By (Aosta) via the low pass of Petit Bernard.

All former reasoning, however, does in no way account for the vast gap between the two populations of *D. meregallii* in a relatively short time frame and the filling of the gap with a complex variety of populations of high alpine species competing for the same extreme habitat. The current situation of knowledge about these *Dichotrachelus* species seems to warrant Winston Churchill's famous dictum from 1939 of the riddle, wrapped in a mystery, inside an enigma. Further research on high alpine beetles and their biogeography and phylogeny is urgently needed.

Dichotrachelus sonjae sp. nov. adds another one to the short list of endemic species between river Toce and Lago Maggiore: the Carabidae *Amara constantini* Binaghi, 1946 and *Trechus ceresai* (Taglianti et al. 1998).

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Supplementary material 1

Additional information

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Data type: docx
Explanation note: **table S1.** Data of consulted specimens used for mapping of the sister species *D. leptontinus* and the remarkable discontinuous distribution of *D. meregallii* from the collections of the NMB, NMBE, cAS, cCG, cVR and the references Germann (2011b), Osella (1971); **table S2.** p-distance Matrix of selected *Dichotrachelus* species; **table S3.** DNA barcode (cox1) of *D. sonjae* sp. nov. paratype specimen in FASTA format.
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